Using Real-Time Lexical Indicators to Detect Performance Decrements in Spaceflight Teams: A Methodology to Dynamically Monitor Cognitive, Emotional, and Social Mechanisms That Influence Performance

Completed Technology Project (2013 - 2017)

Project Introduction

Future exploratory long-duration missions will incorporate a crew of six on a mission length of approximately 2.5 years. Challenges include the requirement for the crew to function autonomously, under significant communication delays, and with the potential for increased crew and interpersonal friction or tension. The specific aims of this research are to (1) develop a methodology to assess cognitive and emotional state at a distance though analysis of spontaneous verbal output in real-time communications and (2) test the feasibility of a real-time assessment tool, STRESSnet, to detect cognitive performance deficits, stress, fatigue, anxiety, and depression in the spaceflight operational setting.

Because the health and well-being of crew members directly affects mission success, it is important to track cognitive/emotional changes that may indicate a deficit. One problem with many existing assessment methods is that most require direct observation of behavior or performance or self-assessment by a pen and paper-type instrument. The requirement to assess individual and team functioning at a distance suggests the potential efficacy of a methodology to assess cognitive and emotional state in real-time from ongoing or spontaneous verbal output. The basic premise of this work is that spontaneous verbal output provides a natural and valid indicator of basic cognitive processes. Natural word use is not prone to the typical limitations of self-report measurements. That is, natural language use is less subject to social desirability bias, and can be derived in real-time without interfering with the cognitive processes being measured, and without interrupting crew performance. Moreover, natural word use is reliable and consistent across time and context, and can be meaningfully measured in individuals and teams.

STRESSnet is a lexical analysis tool designed to provide a non-obstrusive means of detecting stress and related deficits in long-duration spaceflight through the assessment of spontaneous verbal output in real-time crew communications. The research builds on existing work on text and sentiment analysis; however, STRESSnet is unique in that (1) it is specifically designed to assess stress and related cognitive/emotional states, (2) we draw on existing astronaut communications and mission logs to develop a lexicon that includes terms unique to this environment, and (3) we developed STRESSnet with the specific goal of application as a tool to assess user state and provide automatic schedule recommendations for crew work/leisure activities to counter identified deficits.

This report summarizes data derived from testing STRESSnet in the Human Exploration Research Analog (HERA) 3 campaign. In summary, the HERA 3 data results are consistent with and support the results observed in the HERA 1 and HERA 2 campaigns. Our overall research goals are to: (1) Demonstrate that the lexical indicator measure (STRESSnet) correlates with existing

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cognate pen-and-paper measures of stress. (2) Demonstrate that the lexical indicator measure (STRESSnet) is sensitive to differences in operational variability, such as levels of workload or stress. (3) Demonstrate that the lexical indicator measure (STRESSnet) is sensitive to other variables of interest, such as within-group or between-group differences.

The HERA 3 data described in the following sections indicate that the primary STRESSnet lexical measures of Social Impairment, Anxiety, Cognitive Load, and Attentional Focus were consistent with pen-and-paper measures of these same constructs. Negative affect as measured by Positive and Negative Affect Schedule (PANAS) was very low across Campaign 3 missions and this lack of variability resulted in inconsistent relationships with lexical measures of negative emotion. Second, STRESSnet measures for each primary facet consistently differentiate between high and low workload days in HERA. Third, STRESSnet measures were sensitive to differences in the type of communications (e.g., task-oriented vs. non-task oriented communications). Fourth, using STRESSnet measures of anger and cognitive anxiety, we were able to identify a reported elevated episode of anger in one mission, demonstrating the utility of this approach for diagnosing crew stress and well-being during long duration spaceflight.

Anticipated Benefits

Because the health and well-being of crew members directly affects mission success, it is important to track cognitive and emotional changes that may indicate a deficit. The requirement to assess individual and team functioning at a distance suggests the potential efficacy of a methodology to assess cognitive and emotional state in real-time from ongoing or spontaneous verbal output. The basic premise of this work is that spontaneous verbal output provides a natural and valid indicator of basic cognitive processes. Natural word use is not prone to the typical limitations of self-report measurements, which include social desirability bias, and it can be derived in real-time without interfering with the cognitive processes being measured, and without interrupting crew performance. Moreover, natural word use is reliable and consistent across time and context, and can be meaningfully measured in individuals and teams.

The major accomplishments of this research project include (1) the development of a theoretical model of cognitive performance deficits, stress, fatigue, and anxiety in spaceflight based on existing research on lexical analysis and language usage in astronauts, (2) the development of a lexical analysis tool, STRESSnet, to unobtrusively track and assess stress in individuals and teams, and (3) the implementation and empirical testing of this approach in HERA1, HERA2, HERA3. The STRESSnet tool will permit dynamic, unobtrusive detection of stress and related cognitive deficits during

Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Organization:

National Space Biomedical Research Institute (NSBRI)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Principal Investigator:

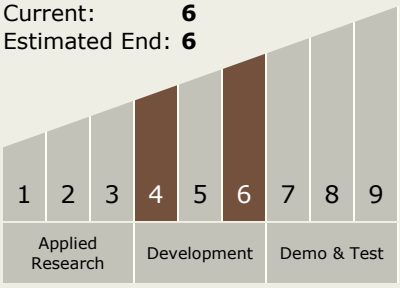
Eduardo Salas

Co-Investigator:

James Driskell

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



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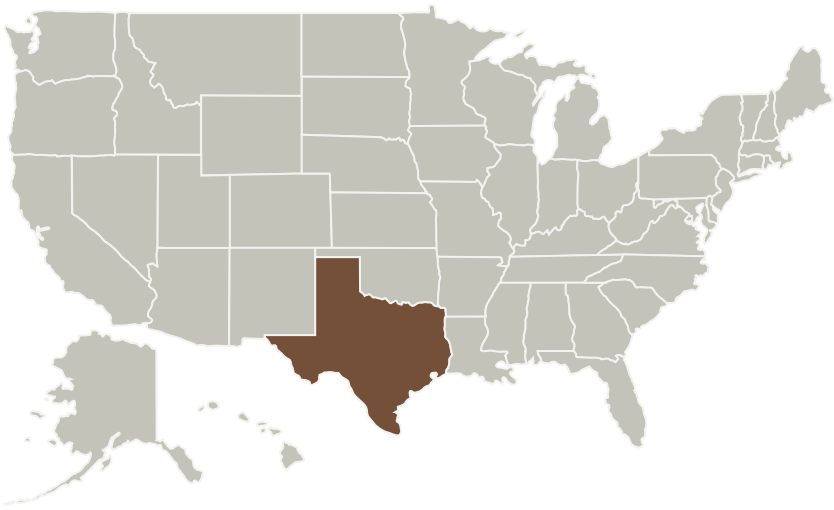
spaceflight, and many Earth-based applications. It is expected that a real-time assessment and graphical display of stress effects, as well as measures of fatigue, mood, and team functioning drawn from ongoing verbal or textual communications, could be used in healthcare, military, education, law enforcement, and many other workplace applications. It also has the potential to contribute to the growing market for sentiment analysis tools in social media and online communications.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
National Space Biomedical Research Institute(NSBRI)	Lead Organization	Industry	Houston, Texas
Florida Maxima Corporation	Supporting Organization	Industry	Winter Park, Florida
Rice University	Supporting Organization	Academia	Houston, Texas

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.3 Human Health and Performance
    - TX06.3.3 Behavioral Health and Performance

Target Destinations

The Moon, Mars

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Primary U.S. Work Locations
Texas

Project Transitions

August 2013: Project Start

May 2017: Closed out

Closeout Summary: The Year 1 tasking was to conduct a proof-of-concept study to demonstrate the feasibility of this appr oach in the HERA 1 analog. This was accomplished, demonstrating that (a) lexical measures can distinguish between high s tress and nominal stress in HERA, (b) these measures are consistent with traditional pen and paper measures of stress, and (c) they show sensitivity to variations in stress levels (documented in the Year 1 technical report). Year 2 research efforts f ocused on extensive development of the lexical analysis tool, STRESSnet, that is specifically tailored to assess stress effects in the LDSF (long duration space flight) environment. This included the methodological development of the STRESSnet prog ram and corresponding lexical dictionaries (documented in the Year 2 Annual Report). Year 2 tasks also included data collec tion and analysis testing this approach in the HERA 2 campaign. Year 3 tasks included the HERA 3 campaign data collection and analysis. The project deliverables include: (1) STRESSnet program code, (2) validation data from three HERA campaign s: HERA1, HERA2, HERA3, (3) dictionaries of searchable terms that could be used by NASA for nonintrusive detection of per formance-relevant changes in cognitive, emotional, and social interaction, and (4) Scientific reports describing the use of le xical measures to assess stress-related deficits in spaceflight.

Stories

Articles in Other Journals or Periodicals
(https://techport.nasa.gov/file/64713)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/64716)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/64708)

Articles in Peer-reviewed Journals
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Project Website:

https://taskbook.nasaprs.com